Restoring Tidal Hydrology
Breaking Down Barriers

Fostering an exchange of information among experienced and potential practitioners of tidal hydrologic restoration in the U.S. Southeast region

Workshop Proceedings

January 2008
Charleston, South Carolina

NOAA Restoration Center
NOAA Coastal Services Center
National Oceanic and Atmospheric Administration
2008

Restoring Tidal Hydrology: Breaking Down Barriers Workshop Proceedings

NOAA Restoration Center
Office of Habitat Conservation
National Marine Fisheries Service

NOAA Coastal Services Center
National Ocean Service

May 2008

U. S. Department of Commerce
Carlos M. Guitérrez, Secretary

National Oceanic and Atmospheric Administration
Vice Admiral Conrad C. Lautenbacher, Jr., USN (Ret.)
Under Secretary for Oceans and Atmosphere

National Marine Fisheries Service
James W. Balsinger, Acting Assistant Administrator for Fisheries

National Ocean Service
John H. Dunnigan, Assistant Administrator

Suggested citation:

NOAA Restoration Center. 2008. Restoring Tidal Hydrology: Breaking Down Barriers: workshop proceedings. NOAA Coastal Services Center, Charleston, S.C. NOAA/CSC/RPT 08-3.

Limited copies of this document may be obtained from:

NOAA Restoration Center
Office of Habitat Conservation
NMFS, NOAA
1315 East-West Highway, F/HC3
Silver Spring, MD 20910
(301) 713-0174

Or online at:

http://www.nmfs.noaa.gov/habitat/restoration/publications/tech_glines.html

These proceedings were funded by the National Oceanic and Atmospheric Administration (NOAA) Restoration Center and Coastal Service Center. All materials were compiled and edited by the workshop committee members listed below. Abstracts and presentations are included in lieu of full papers, as requested by the workshop organizers, and abstracts vary in length at the preference of the author. Some presentations have been modified from their original version under direction of the author to avoid the inclusion of material that may have use limitations. Presentations have not undergone peer review, and the content is the sole responsibility of the author(s). Sponsors make no warranty with respect to the use of any information included. Views expressed are those of the authors, and do not necessarily reflect the views of the sponsors. This document does not constitute a formal publication, and is being distributed with the intent of facilitating information sharing only. Its contents should not be copied or reproduced without the express permission of the individual author. Reproduction in these proceedings does not preclude supplementation and further publication of work in reviewed journals or similar productions.

Workshop Committee:

Leslie Craig, NOAA Restoration Center
Bethney Ward, NOAA Coastal Services Center
Krista McCraken, I.M. Systems Group/NOAA Coastal Services Center
Howard Schnabolk, I.M. Systems Group/NOAA Restoration Center

Table of Contents

Letter to the Reader:

These proceeding are intended to provide a summary of the information gathered from a two-day workshop conducted by the NOAA Restoration Center and the NOAA Coastal Services Center on tidal hydrology restoration in the southeastern U.S. The workshop was designed to promote information exchange among tidal hydrology restoration practitioners and experts regarding past and potential restoration opportunities. The workshop focused on removing barriers to achieve reintroduction or enhancement of tidal influence in estuarine areas through such techniques as levee breaching, causeway removal, and culvert placement.

The workshop included five breakout sessions, four plenary discussions, and several panel discussions.

Breakout session topics: Design, construction and maintenance, permitting, scientific evaluation, coordination, and community involvement

Plenary topics: Tidal marsh restoration and creation, numerical modeling, response of tidal wetlands to climate change, scientific evaluation

The following pages include summary notes from each of the breakout sessions (pages 9-30) and abstracts from the four plenary presentations (pages 31-34). The summary notes capture the discussion during each session but do not synthesize or evaluate the importance or relevance of the information. However, specific recommendations noted in the discussions are highlighted in the “conclusions” and “recommendations” sections. These proceedings, along with additional research and expert input, will provide the basis for development of a NOAA guidance manual to aid practitioners in conducting tidal hydrologic restoration (to be completed in autumn of 2008).

Workshop Background

Introduction

Tidal hydrologic restoration projects—that is, projects to restore natural tidal flow—have been implemented across the southeastern U.S. in order to restore fisheries habitat that has been impacted by decades of anthropogenic alterations to natural tidal flow and influence. Once tidal flow is restored to these areas, habitats are able to recover with little additional labor. For this reason, hydrologic restoration projects deliver a "big bang for the buck" and provide an avenue for true restoration.

In recent years, interest in this type of restoration has been on the rise. Resources are becoming more readily available, and the number and scale of projects have increased. As more resource professionals engage in this type of activity, the opportunity exists to enhance the science surrounding the discipline and increase efficiency. However, to date, this process has been hindered, as information sharing among projects and restoration practitioners has been lacking.

On January 16 to 17, 2008, The NOAA Restoration Center and NOAA Coastal Services Center hosted a workshop in Charleston, South Carolina, titled, "Tidal Hydrology Restoration: Breaking Down Barriers" with the goal of promoting information exchange among experienced and potential practitioners of tidal hydrology restoration in the southeastern U.S. Approximately 75 experts, practitioners, and coastal managers from government, nonprofit organizations, academia, and the private sector attended the event.

While hydrologic restoration can take many forms, this workshop focused on removal of barriers to achieve reintroduction or enhancement of tidal influence into a specific area. Examples of this type of project include the following: culvert placement under roads to allow for tidal flooding of impounded marsh habitat; causeway removal and bridge construction to allow for tidal flow between bays; and breaching levies to allow for tidal flooding of wetland.

Workshop Design

In the fall of 2007, NOAA staff recruited 13 experts associated with various aspects of tidal hydrologic restoration to help design and implement the workshop. Several meetings were held over the following months until the workshop agenda was finalized.

Over the course of the two-day workshop, the agenda included four plenary discussions, five breakout sessions, and several panel discussions. Breakout sessions were each one and one-half hours in duration and included the following topics: design; construction; modeling; permitting; scientific evaluation and coordination; and community involvement.

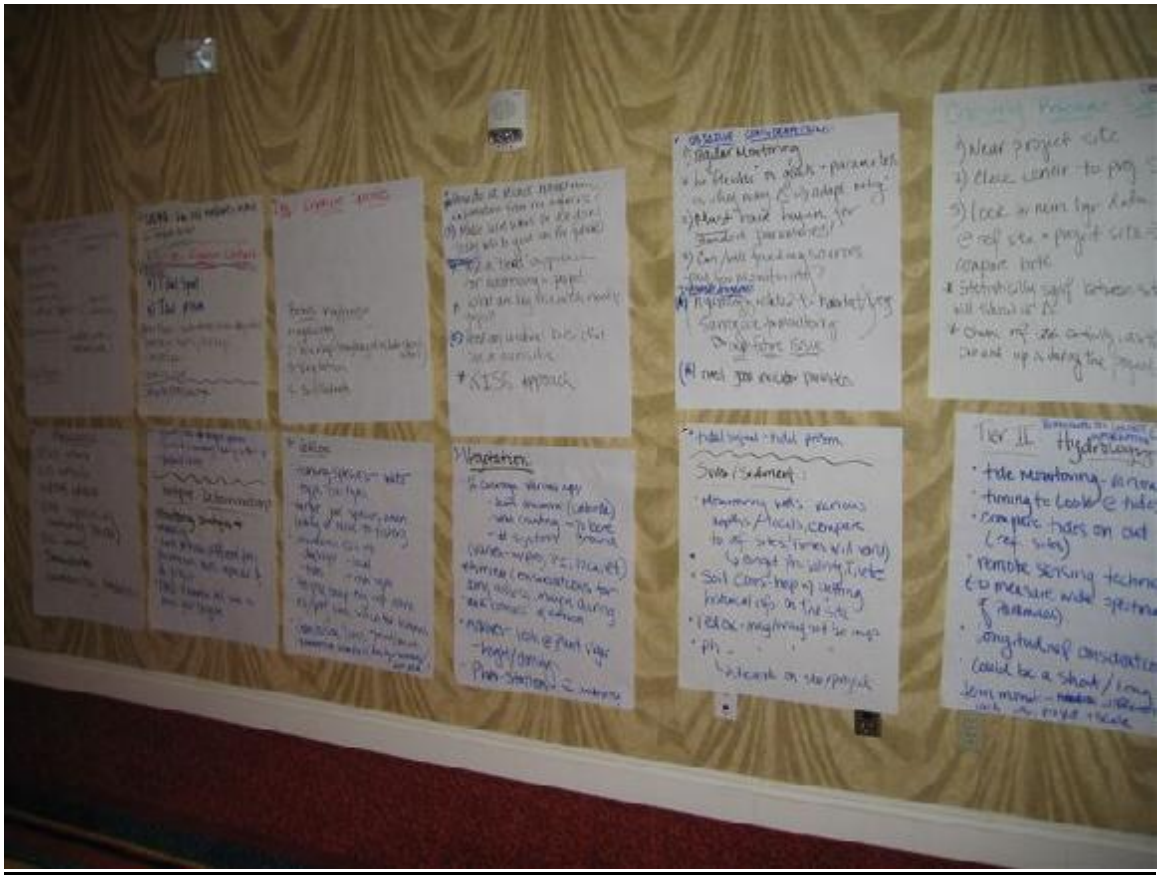
The following proceedings include abstracts from the four plenary presentations and summary notes from each of the breakout sessions. These proceedings will form the basis for the forthcoming development of a guidance manual for tidal hydrologic restoration practitioners. This document, to be completed in fall 2008, will be distributed to workshop attendees and available to the general public.

Workshop Objectives

- To foster an exchange of information among experienced and potential practitioners of tidal hydrologic restoration in the Southeast region

- To increase participants' knowledge of hydrologic restoration planning processes

- To identify gaps in knowledge, research, and tools related to hydrologic restoration



Breakout Sessions

Session Goal:

- To provide an open forum for brainstorming, exchanging information, and achieving consensus (when possible) among professionals experienced with hydrologic restoration projects and professionals considering hydrologic restoration project implementation.

Session Strategy:

- Five topics were chosen for breakout-session discussion: design; construction and maintenance; permitting; scientific evaluation; and community and social aspects.
- A team of two or three experts on each topic facilitated the breakout session discussion. These experts developed a list of topics and questions to be addressed during each session These questions and topics served as a guide but did not dictate the conversation.
- Workshop participants chose the breakout session best-suited to their interests or areas of expertise.

Session Outcomes:

- Plenary panel discussion and feedback session
  During a plenary panel discussion at the end of each day, the breakout session experts and facilitators presented summaries and conclusions reached during individual breakout sessions. These panel discussions and feedback sessions were intended to provide all workshop participants with broad exposure to all workshop topics.

- Post-workshop proceedings and guidance manual
  The workshop discussion has been captured in these proceedings. The NOAA Restoration Center and NOAA Coastal Services Center will utilize the proceedings as a tool to aid the development of a guidance manual targeted toward restoration practitioners.

Breakout Session I: Design

Experts and Facilitators

Experts: Hassan Mashriqui, Louisiana Sea Grant, based at Louisiana State University
Tom Ries, Protecting the Environment Through Ecological Research (PEER), Inc.

Facilitator: Leslie Craig, NOAA Restoration Center

Breakout session objective: to provide project practitioners with strategies to develop appropriate project objectives and achieve those objectives through project design.

Topic #1: Defining Project Objectives

Questions: What biotic or abiotic objectives are typically associated with hydrologic restoration projects? How can projects be designed to meet multiple purposes (e.g., fish habitat, flood control, and other purposes)?

Discussion points:

- Narrowly defined objectives may be detrimental to project success and may result in a project that inadvertently slights one function over another (e.g., a project may successfully allow for daily tidal flooding but not allow for adequate fisheries access).
- Before planning a project, identify and evaluate the basic assumptions regarding a proposed project site. Any false assumptions should be identified and corrected before designing a project. A project designed around false assumptions can lead to unintended consequences and failure.
- The planning process should consider a wide range of project objectives and prioritize them according to the needs or desired values of the specific project.
- It should be recognized that maximizing one objective may decrease the project's effectiveness in achieving other objectives. These trade-offs should be recognized up front.
- It is sometimes difficult to differentiate between the goal of the project and the specific objectives proposed to achieve that goal.
- Project objectives may change over the lifetime of the project, as societal values change.
- Blending multiple objectives may also result in wider constituency support.
- The scale of the project will often impact the objectives (and the appropriate techniques).

Objectives often associated with hydrologic restoration projects in the Southeast region:

- Improving surface water quality (dissolved oxygen, nutrient loads, sediment loads, contaminants, salinity, and temperature)
- Improving groundwater quality
- Creating or enhancing fish habitat

- Creating or enhancing wildlife habitat (for wading birds, inverts, and migratory birds)
- Mitigating storm surge and flood impacts
- Allowing for adaptation to, or accommodation of, sea level rise
- Managing stormwater (such as reducing the rate and quantity of runoff)
- Reducing shoreline erosion
- Improving public access and community stewardship
- Improving habitat longevity and sustainability
- Mimicking periodicity and flushing capacity of the natural tidal regime
- Reducing or controlling invasive species
- Eventual achievement of appropriate natural vegetation community or cover
- Eventual achievement of sediments capable of supporting appropriate vegetation community or cover (e.g., pore water salinity, organic matter, or nutrients)

Topic #2: Site-Specific Background Consideration

Questions: What are the current habitat values? Is the "status quo" good? Should the current system remain as is?

See scientific evaluation breakout session notes:

- Preconstruction data collection at project and reference sites will be key to answering questions regarding current habitat value and function.
- Compare specific parameters at preconstruction project site to those at reference sites to determine functionality.

Topic #3: Design Parameters

Question: What site-specific information is needed to begin the first steps of project design?

- Topography (to varying degrees)
- Bathymetry (to varying degrees)
- Elevation
- Plant communities
- Base map, to highlight habitat types, tidal streams, and other elements
- Tidal prism
- Soil characteristics
- Freshwater inflows (surface and ground)
- Salinity regime
- Species composition (faunal and vegetation, threatened and endangered)
- Adjacent lands (e.g., habitat types)

Feasibility considerations:

- Accessibility for equipment
- Sediment stability
- Private landowner and leaseholder issues
- Cost, funding, and opportunity
- Historic conditions

- Permitting environment
- Local resident input and community concerns

Topic #4: Strategies and Techniques

Questions: What different design strategies or options might project managers consider? Under what conditions are these design options more or less desirable or feasible?

- Culvert placement or repair
- Barrier breach (i.e., holes in the levee)
- Bridge placement
- Tidal creek creation
- Water control structures such as tide gates and weirs
- Creation of mosaic habitats
- Sediment grading or elevation change
- Ditch filling or plugging

Discussion points:

- It may be possible to classify these strategies in terms of active versus passive restoration. Active restoration might include those strategies needing long-term or more intensive maintenance (e.g., water control structures). Passive restoration would entail a one-time action resulting in a self-sustaining system with little long-term maintenance (e.g., levee breech).
- The participants had a preference for more passive forms of restoration but recognized that realistic situations sometimes only allow for active strategies.
- It may be possible and necessary to couple multiple strategies.
- Consider the life span of the project and the life span of the techniques (e.g., how long will a flood gate function before replacement?).
- Carefully evaluate vegetation planting needs. Consider a spectrum of natural colonization, such as planting early successional species to climax communities.
- Incorporate a large proportion of edge habitat.
- Carefully evaluate the number of needed openings and passes. Construct the minimum necessary to allow adequate flooding and residence time, since some passes will close if tidal flow is not adequate to maintain all passes. On the other hand, constructing too few openings would restrict access to the restored area by nekton

Topic #5: Global Warming and Sea Level Rise

Questions: What are the implications of storm surge on project design? How do we incorporate flooding concerns and sea level rise and target elevation into design?

Discussion points:

- Incorporation of multiple or mosaic habitat types into the overall design may be an effective hedge against sea level rise. In other words, habitat types may be more able to shift in response to sea level rise.
- Consider designing projects that incorporate high marsh, upland, and freshwater components on larger project sites.

- If Louisiana is an appropriate example, perhaps the breaching of levees to allow for more tidal flooding may be viewed in the future as a cause of saltwater intrusion into freshwater systems.
- Flooding of private property and adjacent land during extreme tidal events must be considered during project design.

Topic #6: Modeling

Questions: When is a model needed? What are the best available models, if any? What inputs and outputs should models include? At what scale does cost become prohibitive?

Discussion points:

- During the permitting process, model results are often requested. Development of a model may give funding agencies more confidence in a project. For small or simple projects, these types of requests and perceptions might artificially inflate costs associated with design, funds which might be better applied to construction or monitoring. Permitting and funding agencies should be careful about these types of requests and weigh the costs and benefits.
- The higher the cost of failure, the greater the need for a model. For instance, if private property might flood with a design that is slightly "off," then the need for a model increases.
- The more complex the tidal flow, the higher the need for a model to inform project design.
- 1-D and 2-D models are likely adequate for most hydrologic restoration project types.
- 1-D models are cheapest and easiest and would be good for small project areas (such as the output of tidal boundary and elevation and the input of tide).
- 2-D models are good for lateral and over-marsh flow (inputs of tide, freshwater flow, rainwater input, and evaporation).
- In order to determine the type of model needed, carefully consider the critical outputs required of the model. The required model outputs will determine the necessary model inputs—which, in turn, determine the type of model required. A project practitioner should be able to approach a modeler with the specific answers that are needed and the modeler will be able to determine the appropriate model.
- Adequate topography and bathymetry are required for model outputs to be accurate.
- Caution: A 1-D modeler will likely think you only need a 1-D model. A 2-D modeler will likely advise you to develop a 2-D model. Seek several opinions.

Topic #7: Resources and Tools

U.S. Army Corps of Engineers. 1991. *Tidal Hydraulics: Engineering Manual*. EM1110-2-1607. *www.usace.army.mil/publications/eng-manuals/em1110-2-1607/basdoc.pdf* (Feb 2008).

U.S. Department of Transportation. 2004. "Tidal Hydrology, Hydraulics, and Scour at Bridges – First Edition." FHWA-NHI-05-077, Hydraulic Engineering Circular No. 25.

The Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA)

Federal Emergency Management Agency (FEMA) Coastal Manual

Technical support:
1. Corporate Wetlands Restoration Partnership – some companies do provide in-kind or matching services.
2. Natural Resources Conservation Service (NRCS) – may have programs for technical support and funding.
3. U.S. Fish and Wildlife Service- several programs offer assistance: Coastal, Endangered Species, Partners for Fish and Wildlife, and Fisheries.

Design Conclusions and Recommendations

A guidance manual may provide practitioners with a wide-ranging list of potential project objectives to consider during project design. Those objectives that do not apply to a specific site can be excluded, and those remaining could be prioritized according to the values of the area.

Narrowly defined objectives may be detrimental to overall habitat functionality.

Know your site! (For example, know the preconstruction conditions.)

“Keep it Simple” should be your first, and preferred, design strategy.

Evaluate a range of strategies and techniques, giving preference to passive (low-maintenance) strategies when possible.

Projects designed to be as compatible as possible with natural ecosystem processes have the best chance to success.

Remember that the type of model required is determined by the questions you need to have answered. Carefully determine the critical questions and then approach a few modelers for their opinions on the appropriate model to develop.

Breakout Session II: Construction and Maintenance

Experts and Facilitators:

Experts: Bart Sabine, Sabine & Waters, Inc.
John Wallace, U.S. Fish and Wildlife Service (Texas)
Kevin Smith, Maryland Department of Natural Resources

Facilitators: Howard Schnabolk, NOAA Restoration Center
Bethney Ward, NOAA Coastal Services Center

Breakout session objective: Provide project practitioners with practical approaches for defining and implementing construction and maintenance objectives. Overall consideration for each topic: how does scale affect general recommendations?

Topic #1: Preconstruction

Question: How do you budget for hydrologic restoration projects?

- The participants felt it was important to have accurate cost estimates. However, this was a challenging task, because there are few people who can estimate project costs well.
- Cost estimates will be driven by size of project, time of year, and local economy.
- Project costs may also vary regionally.
- Funding sources or mechanisms will affect the budgeting and bidding process. Private funding may be more flexible than government funding.
- Budgets should allow for hiring qualified site designers and engineers, but it is often hard to find funding for this aspect.
- Some discussed whether design, permitting, and construction costs should be separated out. Separating costs may reduce the actual cost of construction—or conversely, costs may be saved if the bids are "lumped together."
- Consider the following issues, which may affect the project costs and should be factored into the budget: site accessibility, on-site equipment needed, site contaminants, and amount of earth that might need to be moved (and the required distance to move it).

Question: Are there tools to estimate these costs?

- It was cautioned that there is no "cookbook" for restoration costs because projects will always be site-specific. However, all participants thought it would be helpful to see rough costs for different design practices from other projects, perhaps in a published database (NOAA and local agencies may have some of this information). It would be helpful to see rough costs over a range of example projects, such as a small, nongovernmental organization project and a large state project.
- Statistical basics and regional multipliers can be used to estimate costs.
- Working closely with contractors can be useful for estimating costs.

Question: What information should be included in the statement of work (SOW)?

- Include as much detail as possible in the SOW.
- Avoid change orders in the SOW, if possible.

Questions: What strategies are effective for contractor selection? What expertise should a contractor provide? What about marine contractors?

- Preconstruction conferences with potential contractors is important, because this allows them to prepare better bids if they've viewed the site, and it also may cut down on bid addendums. Site visits are especially prudent for nonlocal contractors.
- Seek qualified site designers and engineers. Academic and private consultants are good sources.
- Contractors may be more knowledgeable than consultants.
- For small-scale projects, it might be advantageous to use local contractors because of their local knowledge. However, the pool of qualified contractors to select from locally may be small.
- Allow contractors to propose their own alternatives and techniques.
- Marine contractors are not generally recommended for this type of restoration.
- Keep options open to considering nontraditional contractors, which may keep project costs down. (A project example was provided in which local prisoners assisted with laying hay bales of natural vegetation for channel bank stabilization.)

Other discussion points:

- Setting priorities within a project may help reduce the cost.
- Pooling resources and partnering with others may be more cost effective.
- A good construction manager can help reduce costs.
- A more comprehensive list is needed of potential funding sources for restoration.

Topic #2: Construction

Question: What can be done to ensure construction quality?

- The participants agreed that independent oversight is critical, including for permitting (the project may cost more money in the long run if this is not done).
- Construction oversight meetings should occur on a weekly basis and should include input from the construction manager, design team, and planning team.
- Create agendas for project meetings and site visits, and take notes for the record.
- Projects should be permitted separately from engaging construction contractors to ensure that requirements and objectives are met.
- Changes to the construction plan should be evaluated prior to implementation and on an ongoing basis.
- Local knowledge of the site is necessary, especially if working with nonlocal contractors.
- Consider local events (e.g., hurricanes, if an area is prone to them).
- Identify a "window of time" for construction.

Question: What do you do when construction doesn't go as planned?

- The participants felt it was necessary to have a contingency plan, which would include identifying when it is advisable to "cut your losses," and that the contingency plan should revisited and modified if necessary throughout the project.
- Contingencies arising during construction should be budgeted from the outset.
- It was noted that contractors may have contingency plans but not be sharing them.
- Engaging the design team throughout the entire project is important.
- The participants discussed the importance of translating information among biologists and engineers working on a project. Biologists need to understand how construction equipment works, and engineers need to understand the ecology of the site. Consider hiring companies that have biologists and engineers who already work together.

Topics #3 and 4: Post-Construction Evaluation and Maintenance

Discussion topic: vegetation

- Elevation, spacing, and timing (season) were all recognized as important considerations for planting.
- Some felt it was better to build with sand because it is easier to manipulate during construction, plant healthy vegetation, and fertilize.
- There was some debate among the participants regarding the use of potted plants versus individual sprigs (bare root). Generally, it was agreed that planted vegetation could transition from bare root sprigs in intertidal areas to three-gallon pots (or larger) in upland areas.
- Most agreed that at least three to five years of maintenance is required to combat non-native vegetation on a site.

Discussion topic: design evaluation

- All of the participants felt that it was important to re-evaluate the project design and construction and to monitor the project site over time ("monitor the design").
- Conducting an "as-built" evaluation (to assess changes compared to original design) is important.
- Hydrologic changes should be monitored (not just ecological changes).
- Keep design simple and avoid structures if possible (particularly those requiring maintenance).

Discussion topic: maintenance

- The participants felt that monitoring and maintenance were critical to a project's function over time.
- Typical maintenance issues include management of invasive species, management of structures (such as culverts and tide gates), and identifying responsible parties when changes need to be made.
- There was some discussion regarding whether using local entities for long-term maintenance can be more effective. This may help to foster stewardship and develop new partnerships, but agreements to coordinate this partnership may not be binding. If local maintenance is to be used, maintenance personnel should be integrated into the design and construction phases.

Topic #5: Existing Resources and Needs

Questions: Where do you turn for construction guidance or assistance? How do you find best management practices (BMPs), manuals, or guidance documents? What tools and support are needed?

- Many states have BMPs noted in their regulations.
- Local university students can be an inexpensive resource to help with projects, such as for modeling.
- Communicating project results to others is important, including successes and lessons learned. Mechanisms for doing this may include published literature, meetings, newsletters, and local or regional field trips ("restoration tours").
- If site visits are not feasible, an on-line virtual tour of restoration sites across a region could be developed.
- Site visits are important for understanding how construction works, and site visits are necessary for those involved in project design.

Construction and Maintenance Conclusions and Recommendations:

Accurate cost estimates are important but challenging to do.

A database of example design and construction costs would be very helpful.

Be flexible with contractor specifications to allow for innovation and cost-effectiveness.

Site visits or local knowledge by contractors are necessary for effective project design and construction.

Construction oversight and contingency planning are critical.

After projects are completed or installed, they should be monitored and maintained. The project design and ecological changes should be evaluated.

It is important to share project results with others, including successes and lessons learned.

Breakout Session III: Permitting

Experts and Facilitators:

Experts: Nicole Adimey, U.S. Fish and Wildlife Service
Kevin Smith, Maryland Department of Natural Resources
Pace Wilber, NOAA Fisheries Service
Facilitator: Howard Schnabolk, NOAA Restoration Center

Breakout session objective: to provide project practitioners and regulatory agencies with strategies to navigate and optimize the permitting process.

Topic #1 Addressing Regulatory Requirements

Questions: Which agencies should be consulted in the permitting process?
At what stage should, or can, these agencies become engaged in the planning process?
How do Endangered Species Act (ESA) requirements affect project permitting?

Discussion points:

- Rather than discuss the basics of how to acquire a permit, the panelists decided to present this information in the forthcoming guidance document. Details will include background information on procedures, lists of agencies and their functions, and links to publicly available resources.

Topic #2 Efficiency

Questions: What are the major stumbling blocks to securing the required permits?
What strategies can practitioners adopt to ease the permitting process?
What strategies can regulators or regulatory agencies adopt to ease the permitting process?

Discussion points:

- While it is recognized that the permitting process is tedious and often treats habitat restoration projects in the same manner as development projects, you should not expect it to be simplified anytime soon for restoration efforts. Instead, learn to work within the current framework of the system; be patient and persistent.
- Include restoration projects within a larger water management plan or other larger regional efforts. Water management districts often have established inroads with permitting agencies and turnaround can be quicker.
- Your efforts to acquire a permit will be greatly enhanced when you take time to develop relationships with the individuals from the various permitting offices; kindness can go a long way. Also, try to get assistance from more experienced individuals—perhaps NOAA restoration personnel can help.
- While long-term working relationships with individuals are a key to success, please recognize that permitting agencies experience a high turnover.

Unfortunately, your project may be assigned to a new staff member who lacks experience or follow uncommon procedures.

- The following steps make the permit processor's job easier: provide background information on the project; submit complete application packages; and provide geographic information system (GIS) files electronically, in addition to printed maps. Also, provide a PowerPoint presentation of the project that outlines challenges, benefits, and other considerations. (This should be thorough and brief, so supervisors can get a good feel for the project without being overwhelmed with details).
- Having permits in hand when requesting project funds increases the likelihood that your grant applications will be funded. When this is not possible, establish a permitting plan with the following details: identify points of contact at permitting agencies; list the necessary permits you will acquire; and document any other types of progress made toward permit acquisition.
- Some perceive a major stumbling block with restoration permitting—it is treated in the same way that development projects are handled. More frequent use of Nationwide Permit 27 (which is meant to streamline permitting for restoration projects) would be welcomed as too would special procedures for environmentally beneficial projects when Nationwide Permit 27 is not applicable. Since NOAA is funding a great deal of restoration work within coastal areas, the agency should take the lead in establishing streamlining procedures with the U.S. Army Corps of Engineers (USACE). Currently, a disproportionate amount of money and resources are spent on the permitting process. Maybe NOAA can lead the revival of "joint agency" meetings in areas where the meetings are no longer active. These meetings would be a good venue for promoting more frequent use of Nationwide Permit 27.
- Some states have procedures that make state permits simple to attain for restoration projects. States that do not have these procedures should be encouraged to adopt them.

Topic #3 Opportunities

Questions: Are regulatory agencies able or willing to participate in the planning process? What assistance can regulatory agencies provide to project planners?

Discussion points:

- Hold pre-application meetings with permitting agencies to help them understand project needs and values. Include site visits. Be aware that some will attend and some will not. Ask for a review of the application and incorporate changes before it is submitted. Ask for a letter supporting use of Nationwide Permit 27 for the project.
- The USACE is divided into districts. Each district differs somewhat in its modes of operation. Understand how your local USACE office prefers to work and adapt to the process. For instance, some offices prefer applicants to work directly with the resource agencies that provide comments to the USACE about projects while other offices prefer to moderate these interactions.
- Take advantage of interagency "joint agency" meetings. These meetings provide opportunities for the project proponent to meet with the permitting agents and present project and exchange information with the appropriate agencies and professionals in the permitting chain.

- Revive joint agency meetings in all districts. A participant noted that joint agency meetings are held in some districts but are nonexistent in others. Recent USACE customer satisfaction surveys correlate a high level of satisfaction with districts that schedule regular interagency meetings for permit applications.
- Sometimes engaging with state permitting agents first will help to ease the process with the federal permitting agencies. Federal permits normally cannot be issued until the state certifies to the USACE that the project will meet water quality standards and that the project is consistent with the state's coastal zone management program.
- NOAA Fisheries Service staff members will look into ways to streamline Essential Fish Habitat (EFH) consultation process for restoration projects. This will be a first step in streamlining the permitting process for restoration practitioners.

Existing resources and needs

Where do you turn for permitting guidance and assistance? Are there existing best management practices, manuals, or guidance documents? What tools and support are needed? Are there permit applications and schedules that can be used as a model?

- Refer to U. S. Army Corps of Engineer and state coastal management websites for permitting guidance and forms.
- A tool that provides state specific information regarding permitting processes should be included in the Guidance Document.

Permitting Conclusions and Recommendations

The guidance manual should provide background information and links to resources that are designed to assist a practitioner who has no previous experience in permit acquisition.

The permitting process can be frustrating for practitioners. Make efforts to develop personal relationships with permitting agents. Be patient and polite. Be thorough about your applications to make the job easier for the permitting agency and provide adequate resources, including GIS and other electronic files. Allow for an adequate time commitment to incorporate these recommendations into your approach.

Make use of joint agency project review meetings. In areas where these meetings do not occur, request that meetings be scheduled.

Promote the use of Nationwide Permit 27 during pre-application meetings USACE and resource agencies.

NOAA should lead efforts with USACE to streamline permitting processes. Currently, resources are being wasted on permitting processes.

Breakout Session IV: Scientific Evaluation

Experts and Facilitators:

Experts: David Burdick, University of New Hampshire
Lawrence Rozas, NOAA Fisheries Service

Facilitators: Nicole Adimey, U.S. Fish and Wildlife Service (Florida)
Leslie Craig, NOAA Restoration Center

Breakout session objective: provide project practitioners with practical or straightforward approaches to determining the success of the project at meeting defined objectives (and, potentially, to allow for adaptive management).

Discussion points:

- Funding for monitoring is often limited. Funding agencies typically have a stronger preference for awarding funds for design or construction, not for long-term scientific evaluation.
- Funding agencies typically request or require monitoring information—even when funding is limited for this activity. (This is why it is suggested that if an applicant plans to cost-share or donate "in –kind" services, they should consider the monitoring aspect of the project, which is sometimes very critical for determining success of a project, but is least likely to get funded)
- There was some discussion on the quality of data that can be obtained—and how useful it would be for interpreting project success. When funding for monitoring is very low, the subsequent effort is also low and time frame is brief.
- In general, participants agreed that all projects should receive a basic level of monitoring to provide some degree of confidence that the project is functioning, but that a smaller subset of projects should receive a more robust level of monitoring to better understand aspects of functionality in comparison to reference sites.
- One year of preconstruction monitoring is critical in order to determine the effect of restoration actions. Pre- and post-construction monitoring should include data collection at both project and reference sites.
- Reference sites should be selected that are as close to the project site as possible in space and habitat type. For instance, the National Estuarine Research Reserve System (NERRS) may provide good reference sites with long-term data sets.

Topic #1: Parameters

Question: Based on objectives identified in the "design" breakout session, can we identify standard parameters that should be measured for most hydro projects?

- Chosen parameters should be determined by the highest-priority objectives determined for project design and construction.
- A small standard subset of parameters, or "core" parameters, may be useful in determining the success of achieving many of the typical objectives described for hydrologic restoration projects.

- Data collection on core parameters will be useful in comparing multiple projects through time.
- The discussion focused on four parameters that might be considered core parameters for tidal hydrology restoration: hydrology, vegetation, soil, and nekton.
- Potential metrics for the core parameters:
    1. Hydrology: tidal elevation and footprint, salinity
    2. Vegetation: percent cover, community composition, invasive species
    3. Soil: salinity, redox, texture
    4. Nekton: small juvenile transient species are likely the best indicator of functionality.
    5. It would be useful to develop metrics that correlate data between easily measured structural parameters and those parameters that are a more accurate indicator of habitat functionality (e.g., percentage of vegetation cover correlated to secondary productivity).

Topic #2: Monitoring Techniques

Question: based on the parameters identified, what are some basic techniques to collect this information? How frequently, and for how long, should parameters be monitored?

- Hydrology
    1. Float that shows the highest extent of the high tide
    2. Pressure sensor giving continuous recording of tide height at various locations throughout the project site
    3. Monitoring periods of 14-day minimum, 30 days better, 360 days best—would be influenced by location (tidal periodicity and amplitude)
    4. Could also consider measuring peak flow through a cross-sectional area

- Vegetation
    1. Transects across the project site with quadrats (permanent or randomly selected)
    2. Percent cover—important to calibrate the team for quality control
    3. Collect data several times a year but most importantly at peak biomass (date will vary based on location)
    4. Invasive species—should likely include measures of plant vigor (height, flowers, stem density)
    5. Multispectral imagery—could be considered when the project size is large (i.e. effort required for on-the-ground monitoring would be great)
    6. Photo stations—sometimes difficult to translate into data but still critical to understanding project site history; they have a low cost and high return.

- Soil
  Pore water—establish wells or use sippers
    1. Salinity—will likely tell you the most about hydrology and potential to support different plant communities
    2. Dissolved oxygen – if important for a given site
    3. pH – if important for a given site

- Nekton
    1. Target species of recreational or commercial importance
    2. Target juveniles of species that depend on the marsh for early life stages or transient species (can use young-of-the-year for comparisons between years)
    3. Issues to consider: fish are not evenly distributed, and there are day and night differences and tidal differences
    4. Quantitative sampling could include the following (with stepwise increases in level of sophistication and energy): density, biomass per unit area, growth rates, survival and mortality, and production rates
    5. Potential sampling gear: throw traps, block nets, and lift nets

Topic #3: Determining Project Success

Questions: Which parameters can be measured to determine short-term effectiveness, therefore allowing for potential design modification? Which parameters are more appropriate as long-term measures of success?

- Of the four core parameters, hydrology may be the most useful for determining short-term effectiveness. However, hydrologic forces may cause changes in the system over time that were not accounted for, or easily observed, during design and construction (e.g., channels may deepen or fill and passes may widen or close).

Question: How do we get beyond just counting fish and move closer to understanding how the system is supporting fish?

- Rozas and others have done some work to understand how marsh structure relates to fisheries production, but much more work is needed to have true surrogates for production. (see Rozas and Minello citations in Appendix E)

Question: What monitoring strategies can be employed to determine the footprint of the area benefited by the project activity?

- For projects where tidal waters are reintroduced to a previously “dry” area, determining the footprint is not as difficult. However, it can still be a challenge to determine whether the objectives of the project have been achieved, and over how much area. For instance, the project area may experience 12 inches of water twice a day, but will the soils support vegetation and can fish access it?
- Pre- and post-construction data collection at reference and project sites allows for conclusions to be drawn about the achievement of individual objectives. At a minimum, this will allow you to compare the project site to a reference site. Over time, you can make some comparisons that allow for an understanding of how the project site is functioning in comparison to the reference.
- If you are lacking reference sites, data collection pre- and post-construction would only allow you to compare the project site to literature references, which doesn’t allow for comparison of natural annual or site-specific variation. It would likely take a much longer data-collection period to draw conclusions about the success of the project in relation to specific objectives.

- For projects in which tidal flow is improved (e.g., removal of a causeway between two bays), reference sites and pre- and post-construction data collection will be key to understanding the effect of the project activities.

Topic #4: Furthering Science

Question: How can individual project monitoring and evaluation feed into, or support, the field of hydrologic restoration science?

- There may be opportunities to set core or standard parameters for meaningful geographic regions that will allow for some level of comparison between project sites.
- There was general agreement that all projects should receive a basic level of monitoring to provide some degree of confidence that the project is functioning. However, a smaller subset of projects should receive a more robust level of monitoring to enable better understanding of aspects of functionality in comparison to reference sites.
- The potential exists to unearth data that was collected through the regulatory process for mitigation projects. Typically these projects require at least five years of data collection. The number of projects conducted under the auspices of the regulatory process is likely very high, so the data set should be rich. However, this information may not be readily available from regulatory agencies or maintained in a format that is useful for scientific comparison.

Question: What are the appropriate outlets to compile and share data?

- At this point, some agencies are making databases available on-line (e.g.,the U.S. Fish and Wildlife Service's HaBITS database) to provide data on projects supported or constructed by the agency.

Topic #5: Resources and Tools

U.S. Geological Survey publications
National Park Service publications
NERR protocols
Environmental Protection Agency rapid assessment methodologies
Galveston Bay Foundation citizen-based monitoring protocol

Scientific Evaluation Conclusions and Recommendations:

All projects should receive a basic level of monitoring to provide some degree of confidence that the individual project is functioning. Perhaps a smaller subset of projects should be evaluated more thoroughly to advance the science of coastal restoration.

One year of preconstruction monitoring is critical to determining the effect of restoration actions. Pre- and post-construction monitoring should include data collection at both project and reference sites.

Reference sites should be selected that are as close in space and similar in habitat type as possible.

Chosen parameters should be determined by the highest-priority objectives determined for project design and construction.

Four parameters might be considered standard, or core, parameters for tidal hydrology restoration: hydrology, vegetation, soil, and nekton.

There may be opportunities to set core, or standard, parameters for meaningful geographic regions that will allow for some level of comparison between project sites.

Breakout Session V: Project Coordination and Community Involvement

---

Experts and Facilitators:

Experts: Joe Berg, Biohabitats, Inc.
Tracy Skrabal, North Carolina Coastal Federation
Facilitator: Howard Schnabolk, NOAA Restoration Center

Breakout session objective: provide project practitioners with strategies for identifying projects and partners, building community support for projects, and gaining insight into addressing typical community concerns.

Topic #1 Identifying Project Opportunities

Questions: How are projects identified, prioritized, and initiated? What are typical opportunities that can be exploited?

Discussion points:

- Projects emerge through opportunistic, crisis-mode circumstances or strategic planning.
- Crisis-mode opportunities (e.g., through mitigation or regulatory requirements) while not optimal, are still prevalent and effective. However, you should sometimes say "no" to these opportunities if there is no long-term plan.
- There is a strong need for comprehensive strategic plans that identify and prioritize hydrologic restoration projects on a regional and holistic scale. Current plans are often skewed to reflect the priorities of the organization that has conducted the study. The following are considerations in developing appropriate strategic hydrologic restoration plans:
    1. Must be compatible with larger community, watershed, or regional plans.
    2. Forums need to be provided to identify priorities and get buy-in from a wide range of groups. The Southeast Aquatic Resources Partnership (SARP) is a good example of this type of process.
    3. Plans should be biologically and economically based but should also incorporate other disciplines. Multi-disciplinary planning teams are necessary.

Strategic Planning Criteria:

- Land use
- Project size (< or > 10 acres)
- Cost per acre
- Available funds
- Identified in other plans
- Number of property owners impacted
- Visibility
- Site constraints
- Stewardship value
- Feasibility or likelihood to get support

- Relative importance in the landscape
- Existing habitat values
- Species Impact
- Public access and ecotourism potential

Topic #2 Coordination Mechanisms, Partners, and Funding

Questions: Who are the appropriate coordination organizations? Who are the potential partners and funding mechanisms?

Discussion points:

- Increasingly, corporations are "greening" their images. There are tremendous unexploited opportunities to engage these partners. In the South, many corporations own large tracts of land and are willing to turn over property for public benefit.
- Regionally-based organizations would be best suited to addressing restoration due to scaling issues.
- Easements are also increasing as an option to obtain land for projects. Comprehensive information on various easement concepts should be incorporated into the guidance document.
- Quantifying and communicating gains in property values associated with restored natural areas will provide incentives for property owners to incorporate restoration into development plans.
- Developing compensation mechanisms (through the tax system) to landowners for ecosystem services would also provide incentives for restoration.
- Volunteer time is an important and sometimes overlooked source of matching funds for projects (currently $18.77 per hour).

Funding mechanisms:

- Corporate Wetlands Restoration Partnership
- U.S. Fish and Wildlife Service- several programs offer assistance: Coastal, Endangered Species, Partners for Fish and Wildlife, and Fisheries.
- *NOAA Community-based Restoration Program*
- *CWPPRA-Coastal Wetlands Planning, Protection and Restoration Act(Louisiana)*
- *CIAP-Coastal Impact Assistance Program*
- NOAA Coastal Services Center funds partnership building and coordination
- SARP
- USFWS
- National Coastal Wetlands Conservation Grant Program.
- State grants
- EPA wetland funds: *http://www.epa.gov/owow/wetlands/grantpilot/*
- Fish America Foundation: *http://www.fishamerica.org/grants/*
- National Fish and Wildlife Foundation: *www.nfwf.org/AM/Template.cfm?Section=Home*
- National Estuary Program (indirect): *www.epa.gov/nep/*

- Coastal Conservation Association: *www.joincca.org/*
- Coastal America: *www.coastalamerica.gov/*
- Restore America's Estuaries: *www.estuaries.org*

Topic #3 Generating Community Involvement and Public Support

Questions: How can public support of existing or future hydro-restoration projects be generated? What strategies should be used to educate the public and involve them in the process? What are the typical concerns of local communities regarding hydro-restoration projects?

Discussion points:

- To achieve increases in restoration opportunities, support must be generated through public interactions with local, state, and national legislative bodies. These lobbying efforts can be effectively accomplished through the work of environmental nonprofit organizations who utilize paid staff and volunteers.
- A greater effort needs to be made to market completed projects. Expect marketing efforts to continually improve through experience and familiarity with local outlets.
- All forms of public involvement in projects are a critical component and should not be an afterthought. Outreach and volunteer coordination, in particular, is more involved than it appears and requires significant staff time.
- The level of citizen involvement in projects should be carefully considered depending on the expected level of controversy and your willingness to compromise your objectives.
- Tie the community into the project by relating what the community cares about, keeping in mind that community interests may not relate to the primary goals of your project.
- Utilizing volunteers is not the most effective way to restore, but it is the most effective way to build public education, awareness, stewardship, and support.
- Volunteers are often the only resource available to collect monitoring data. Research shows that with protocols and oversight, data from volunteers can be as valid as any other source. Government and academic institutions perpetuate the idea that volunteer data is insignificant—on the contrary, these activities should be promoted.

Public education and outreach strategies

- Strive to develop a person who is a full-time volunteer coordinator.
- Align with an organization or agency that specializes in outreach, volunteerism, and advocacy.
- Make videos that demonstrate the benefits of restoration projects and utilize local cable channels for free air time. This is a cost-effective strategy, considering the level of viewership.
- Utilize media during construction and volunteer activities. To keep media engaged over long periods of time, vary the type of activities that you present.
- Engage the public in celebration events that center on completed projects.

Volunteer management strategies

- Create realistic timelines regarding the time and effort of volunteers. (For instance, seniors might prefer an intense couple of hours, while students like “laid back” schedules over longer timeframes.)
- Hold individual events and cycle through different volunteer “crops” to avoid burnout.
- Give back sometimes—hold educational events between maintenance activities.
- Have volunteer recognition day, with awarding of plaques and other events.
- Generate volunteers by utilizing existing community service groups. Engage these groups through presentations (for instance, at high school ecology clubs, churches, scout meetings, gardening clubs, 4H, civic and sportfishing clubs, farmers’ markets, local festivals, and other venues).
- Ensure that volunteers who are engaged in monitoring use a standard protocol and are properly trained. Utilize universities to devise monitoring plans for implementation by volunteers.
- Use schools and volunteers to amass a large volume of data and exclude outliers.

Building community support and addressing opposition

- Don’t let immediate stakeholders and landowners be blindsided by a public meeting notice about your project—engage and educate these people early on in the process.
- Incorporating local perspectives and information is important for the project to be successful.
- Utilize success stories to improve education, and utilize simple schematics and visualizations to help public understand concepts. Avoid complex “science talk.”
- Community buy-in up front can also help to expedite the permitting process.
- It is important to assess the level of opposition. If misinformation is widespread, use the media to get correct information disseminated. Don’t be afraid to address opposition, setting the record straight builds support and credibility.
- Encourage proponents to express support through “action alerts” on websites and mailing lists.
- Be willing to re-examine the project if substantial community opposition exists.

Existing resources and needs

Questions:
Where do you turn for coordination guidance and assistance? Are there existing best management practices, manuals, or guidance documents? What tools and support are needed?

A resource list that includes existing tools and strategies should be included in the guidance document.

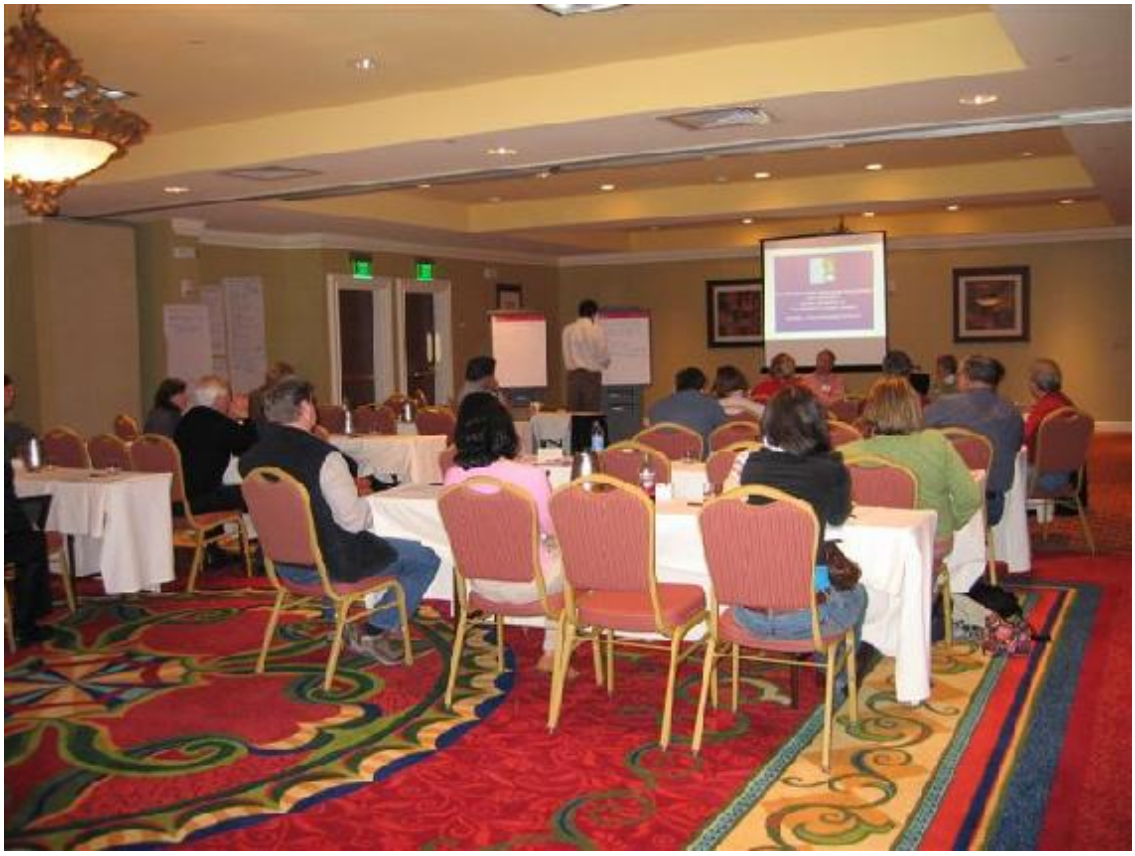
Coordination and Community Involvement Conclusions and Recommendations:

There is a great need to develop regional restoration plans that identify and prioritize projects. A template for developing these plans that can be replicated is also needed.

Corporations are an untapped resource that could have a large impact on future restoration through the donation of funding and land holdings.

Marketing of completed projects and promoting restoration to government bodies are two key strategies that will enable an increase in project funds.

In light of the importance of outreach and the workload it entails, you should consider developing full-time outreach staff positions for your restoration program.



Plenaries

Plenary: Tidal Marsh Restoration and Creation—Keys to Success

Stephen Broome, North Carolina State

Saltwater and brackish water tidal marshes are biologically productive transition areas between land and water that occur in the intertidal zone of estuaries and other low-energy coastal environments. Dredging, filling, tidal restrictions, subsidence, and erosion cause degradation or losses of tidal marshes. To mitigate those losses, methods have been developed to restore and create marshes that provide habitats similar in structure and function to natural marshes. Creating a fringe of marsh vegetation is also an effective method of erosion control along some shorelines. Important site-related factors that must be considered to ensure successful establishment of marsh vegetation are hydrology (elevation, slope, tidal regime, and seepage), wave climate, currents, salinity, and soil physicochemical properties. Agronomic practices that are important to establish vegetation include selection of native plant species adapted to the site, seed collection and storage, seedling production, site preparation, soil testing, soil fertility, handling of transplants, timing of planting, plant spacing, control of undesirable invasive plants, and maintenance until the marsh is self sustaining. The criteria used to define successful restoration or creation is often controversial. Plant communities usually achieve structural and functional equivalence in a few years, while other characteristics such as soil organic matter and numbers and species of benthic invertebrates require much longer to reach equivalence. When the best available technology is properly applied, tidal marshes can be restored or created that provide many of the same functions and values as natural systems.

Major Points for Consideration

- More than half of the marshes in the U.S. are destroyed by draining, diking, dredging, filling, and similar practices.
- Loss of marshes has declined in recently history due to regulation and restoration.
- From 1954 to the 1970s, marsh loss averaged 19,000 hectares per year. From the 1970s to the 1980s marsh loss averaged 2,900 hectares per year.
- Vegetation success is related to the following:
    1. Appropriate elevation, hydrology, and zonation
    2. Protection from wave energy
    3. Nutrient levels
    4. Salinity tolerance and adaptation of vegetation species
    5. Using local transplants or seed source will enhance success
    6. Control invasive species
    7. Remove debris
    8. Maintenance replant as necessary in early stages
- Time required for a given restored marsh to reach functional equivalence with a natural marsh will vary.
- Time required for functional equivalence will be a function of the indicators chosen and measured.

Plenary: Numerical Modeling for Coastal Restoration Projects

Hassan Mashriqui, Louisiana Sea Grant and Louisiana State University

Numerical modeling could be a vital tool to evaluate pre- and post-project impacts on coastal processes due to restoration changes in the landscape. Modeling uncertainties and sources of error, such as errors in the input data, model physics, and model validation must be understood before using a model for any project. Both engineers and scientists designing a project should be aware of these uncertainties and inaccuracies resulting from numerical modeling. In this presentation we will show how modeling could be used to relate coastal processes to the interaction of a particular project or structure, its design lifetime and cost.

Major Points for Consideration

- Oftentimes one must use a combination of models and the best professional judgment due to resource constraints (such as time, finances, and other factors).
- Modeling is most useful when information is needed about pulsing events:
    1. Storm impacts
    2. River switching
    3. Flooding
    4. Tidal patterns
- Modeling considers event, timescale, and impact
- Typical modeling inputs include:
    1. Runoff
    2. Rainfall
    3. Evaporation
    4. Tidal and wind patterns
    5. Bathymetric and topographic data (critical to have accurate data)
- Modeling tools include:
    1. 1-D hydraulics (flood, nutrients)
    2. 2-D (hydrodynamics, nutrients)
    3. Ecosystem models with hydrodynamics (landscape change)
    4. Water quality models
- Modeling constraints and issues:
    1. Cost—geographic information system technologies, hardware, hydrographic surveys are expensive
    2. Federal in-house modelers often have different outputs from academic modelers. These may end up being at odds with each other.
    3. Modeling outputs may not favor current design techniques

Plenary: Responses of Coastal Tidal Wetlands to Climate Change

Scott Neubauer, Baruch Marine Field Laboratory, University of South Carolina

Tidal wetlands have evolved and persisted throughout changing environmental conditions for thousands of years and therefore have an inherent capacity to respond to future environmental changes. However, current and future changes, driven in large part by direct human impacts on climate and the landscape, are faster than historical rates of change and therefore may stress the stability of coastal wetlands. The current, broad distribution of tidal wetlands indicates that these systems can persist across wide gradients of climate, hydrology, and nutrient loading. Comparisons across these gradients provide insight into the changes that may occur as individual wetlands are subjected to a changing environment. In this presentation, I will focus on several environmental changes that are likely to affect many coastal wetlands: sea level rise, global warming, and increases in atmospheric CO_2; and eutrophication-related changes in water quality. In the case of tidal wetlands at the freshwater end of estuaries, sea level rise will not only result in higher water levels but may also bring salt into systems that have historically not been exposed to sea water. Together, these environmental changes are likely to impact the distributions of both individual organisms and entire ecosystems, with migrations occurring northward (in response to warming) and landward or upstream (in response to rising sea levels). The integrative effects of climate change are also likely to impact rates of primary and secondary production, carbon and nutrient storage, and biogeochemical cycling within coastal wetlands.

Major Points for Consideration

- Different wetland types and locations will result in variable responses to sea level rise.
- Greenhouse gases are the highest in 600,000 years.
- In the southeastern U.S., surface temperatures will be 2.3 to 3.3 degrees Celsius higher by 2100.
- Species distributions are already shifting.
- As temperatures increase, rates of decomposition will also increase—potentially leading to shift in species distribution to those that favor these conditions.
- Marshes have some ability to adjust to sea level rise:
    1. Through horizontal migration
    2. Increased vertical height through increased plant production resulting in increased rates of sediment accretion
- Relative rate of SLR will depend on location (i.e., sediment accretion rates and subsidence versus uplift).
- Sea Level Affects Marshes Model (SLAMM) model—shows the total area of tidal marsh as decreasing along N.C. coast. However, freshwater marshes are eventually squeezed between the tidal and upland systems.

Plenary: Scientific Evaluation—Syncing Project Objectives and Evaluation

David Burdick, University of New Hampshire

Monitoring serves management goals at local to regional scales. Ultimately, monitoring should inform management of impacts and threats to tidal marshes and benefits from restoration. A suite of monitoring protocols reflecting marsh values important to society were developed over 10 years of inclusive regional meetings. Results from 36 sites in the Gulf of Maine are presented, indices reconsidered, and next steps proposed.

Major Points for Consideration

- Considerations from the start:
    1. Restoration goals
        A. Restore to a certain point in time?
        B. Restore to a particular functional habitat?
    2. Systems are maintained by positive and negative feedbacks and these should be understood:
        A. Ecological services—always keep in mind the larger ecological system or model
- Identify values that are important to stakeholders:
  Values include food web support, mosquito control, sportfish production
- Determine functions that support the important values
- Develop monitoring indicators for those functions:
    1. Structural indicators, such as vegetation, pools and creek form
    2. Functional indicators, such as primary production and fish movement
- Monitoring recommendations:
    1. Use well-established methods
    2. Have buy-in from regional (not just local-scale) team
    3. Prioritize monitoring into tiers:
        A. Indicators that are always evaluated
        B. Indicators chosen relative to project goals or objectives
        C. Indicators for projects with intensive monitoring

Guidance Manual Development: Recommendations from Workshop Participants

Below is a list of recommendations that were solicited from participants regarding the forthcoming development of a Guidance Manual:

- The guidance manual should examine freshwater marshes, consider if the guidance provided for tidal marshes is applicable, and consider the implications on anadromous fish.
- Lack of pristine reference sites may be problematic. The guidance manual might provide some guidance on best alternatives.
- The guidance manual might include decision-making tools such as checklists, lists of potential objectives to consider, state-specific resources, permitting guidelines and tips, NERR monitoring information, templates for data collection and databases, and worksheets and spreadsheets.
- Perhaps the guidance manual could be dynamic by having components that are available for download and revision on the Internet (i.e., spreadsheets).
- Outside expert review of proceedings and guidance manual is recommended.
- Review of proceedings and guidance manual by future potential users would also be helpful to ensure it meets identified needs.
- Inclusion of appendices specific to each state may be a useful tool. It could include information relating to available data, topography, aerial photography, bathymetry, permitting contacts, and other specifics.
- The guidance manual might be organized by region.
- The manual might be equal parts “how-to” guide and decision-making tool.
- The audience for the guidance manual will likely be coastal managers and restoration practitioners.

Appendices

A: Agenda

B: Moderator and presenter biographies

C: Participant list

D: Evaluation form

E: Relevant literature list

Appendix A: Workshop Agenda

Wednesday, January 16

7:45 – 8:30 a.m.	**Registration – Outside Emerald Ballroom** **Continental Breakfast**		
8:30 – 10:00 a.m.	**Welcome and Logistics – Emerald Ballroom** *NOAA* **Tidal Marsh Restoration and Creation: Keys to Success** *Stephen Broome, North Carolina State* **Numerical Modeling for Coastal Restoration Projects** *Hassan Mashriqui, Louisiana Sea Grant and Louisiana State University* **Breakout Session Intro: Goals and Ground Rules** *NOAA*		
10:00 – 10:20 a.m.	**Morning Break with Coffee**		
10:20 – 11:50 a.m.	**I. Design – Emerald** *Hassan Mashriqui* *Thom Ries*	**II. Construction – Opal Room 2** *Bart Sabine* *John Wallace* *Kevin Smith*	
12:00 – 1:15 p.m.	**Lunch (*provided*) – Emerald Ballroom, Salon 3**		
1:15 – 1:45 p.m.	**Responses of Coastal Tidal Wetlands to Climate Change – Emerald** *Scott Neubauer, Baruch Marine Field Laboratory, Univ. of South Carolina*		
1:45 – 1:55 p.m.	**Transition to Afternoon Breakout Sessions**		
1:55 – 3:25 p.m.	**I. Design – Emerald** *Hassan Mashriqui* *Thom Ries*	**II. Construction – Opal 2** *Bart Sabine* *John Wallace* *Kevin Smith*	**III. Permitting – Opal 1** *Nicole Adimey* *Kevin Smith* *Pace Wilber*
3:25 – 3:55 p.m.	**Afternoon Break with Snacks**		
3:55 – 5:00 p.m.	**Report-Out from Breakout Sessions, Panel Discussion – Emerald** *All moderators*		
5:00 p.m. – ?	**Happy Hour at Marriott's Sapphire Grill**		

Thursday, January 17

7:45 – 8:15 a.m.	**Continental Breakfast – Outside Emerald Ballroom**	
8:15 – 8:45 a.m.	**Scientific Evaluation: Syncing Project Objectives and Evaluation – Emerald** *David Burdick, University of New Hampshire*	
8:45 – 9:00 a.m.	**Transition to Morning Breakout Sessions**	
9:00 – 10:30 a.m.	**IV. Scientific Evaluation – Emerald** *Nicole Adimey* *David Burdick* *Lawrence Rozas*	**V. Coordination and Community Involvement – Opal** *Joe Berg* *Tracy Skrabal*
10:30 – 10:50 a.m.	**Morning Break with Coffee**	
10:50 a.m. – 12:20 p.m.	**IV. Scientific Evaluation – Emerald** *Nicole Adimey* *David Burdick* *Lawrence Rozas*	**V. Coordination and Community Involvement – Opal** *Joe Berg* *Tracy Skrabal*
12:20 – 1:30 p.m.	**Lunch (*provided*) – Emerald Ballroom, Salon 3**	
1:30 – 3:15 p.m.	**Report-Out from Breakout Sessions, Panel Discussion – Emerald** *All moderators* **Evaluation** *NOAA* **Closing Remarks** *NOAA*	

Appendix B: Plenary Speaker and Expert Biographies

Nicole Adimey
Nicole Adimey is a biologist with the U.S. Fish and Wildlife Service in Jacksonville, Florida. She has been with USFWS for a little over seven years working with the manatee and sea turtle recovery programs. Recently her duties have expanded to the Coastal Program, where she intends to develop partnerships and projects focusing on Northeast Florida. Prior to working with USFWS, Nicole served as a contract marine biologist specializing in marine mammals, such as killer whales, monk seals, and spinner dolphins.

Joe Berg
Joe Berg is an ecosystems ecologist certified as a professional wetland scientist by the Society of Wetland Scientists and as a senior ecologist by the Ecological Society of America. His graduate degree from the University of Maryland is from the marine, estuarine, and environmental science program. Berg specializes in restoration ecology and is involved with efforts that include the following: site identification; evaluation of existing conditions; development of restoration concepts; preparation of construction plans; specifications and cost estimates; construction oversight and inspection; performance monitoring; adaptive management planning; regulatory facilitation; and participating in public workshops. He has more than 20 years of experience working in coastal systems, including work on the Atlantic, Gulf, and Pacific coasts.

Stephen Broome
Stephen Broome has 34 years of experience in research and teaching. His research focus is application of the principles of soil science, agronomy, and ecology to environmental conservation and restoration. Interests include propagation and mineral nutrition of coastal sand dune, salt marsh, and freshwater wetland vegetation; habitat creation, restoration, and mitigation; erosion control; constructed wetlands for wastewater treatment; biofilters for nonpoint source drainage; and revegetation of mined land. Broome is a professor at North Carolina State University.

David Burdick
David Burdick holds a Ph.D. in marine sciences from Louisiana State University, and is an associate research professor at the University of New Hampshire's Jackson Estuarine Laboratory. He has been studying coastal habitats, primarily salt marshes and seagrass beds, over the past 24 years. His research focus is the assessment of human impacts and the success of habitat restoration activities.

Hassan Mashriqui
Hassan Mashriqui is a licensed professional engineer and an expert storm surge modeler. He is currently developing coastal hydrologic and hydraulic modeling capabilities for Louisiana Sea Grant for the coastal extension and research program. His research interests include coastal and inland flooding due to hurricanes; hydrodynamic and sediment transport modeling; wetland restoration; river management; geographic information systems; and lidar technology-based environmental modeling. He is actively involved with the School of the Coast and Environment at Louisiana State University in support of numerous coastal restoration research efforts.

Scott Neubauer
Scott Neubauer is the assistant director of the University of South Carolina's Baruch Marine Field Laboratory, where he also holds a position as a research assistant professor. His professional training and interests primarily relate to the biogeochemistry and ecology of coastal wetlands, both saline and freshwater. His education path has taken him from Florida (B.S. from University of Miami) to Virginia (Ph.D. from the College of William and Mary's Virginia Institute of Marine Science. After completing his Ph.D., Neubauer worked as a postdoctoral researcher, studying microbial ecology and biogeochemistry at the Smithsonian Environmental Research Center (Maryland) and also spent a year as a visiting assistant professor at Villanova University (Pennsylvania). He has been in his current position in South Carolina since 2004.

Thom Ries
Thomas Ries holds a B.S. in biology and geology from USF and has been working in the environmental arena in Florida since 1983. He is a founding member and chairman of the board of the nonprofit organization Protecting the Environment through Ecological Research (PEER), Inc.

Lawrence Rozas
Lawrence P. Rozas is presently a research ecologist at the NOAA Fisheries Service, Estuarine Habitats and Coastal Fisheries Center in Lafayette, Louisiana and a member of the graduate faculty (adjunct) in the biology department of the University of Louisiana at Lafayette. His primary research interests are identifying the habitat requirements of estuarine-dependent fishery species, understanding how to successfully restore coastal habitats, and assessing the habitat function of coastal wetlands. Lawrence has conducted research on wetland topics for over 20 years and has over 35 scientific publications. He received a Ph.D. in environmental sciences from the University of Virginia in 1987. He also holds a B.S. degree in wildlife management from the University of Southwestern Louisiana and an M.S. degree in marine biology from the University of North Carolina at Wilmington. Before joining the National Marine Fisheries Service, Lawrence was an assistant professor at the Louisiana Universities Marine Consortium (LUMCON). He is an active member of the Coastal and Estuarine Research Federation and Gulf Estuarine Research Society, Ecological Society of America, American Institute of Biological Sciences, and Society of Wetland

Scientists. Lawrence has served on the editorial board for *Wetlands* (1995 to 1997) and as an associate editor for the journal *Estuaries* (1998 to 2001).

Bart Sabine
Bart Sabine has over 27 years of professional experience in forestry and environmental land management studies. He is the president of Sabine & Waters, Inc. and manages the Summerville, South Carolina office. Sabine has gained extensive experience in forest management while working for large industrial forest products companies and small nonindustrial private landowners. He has worked on several broad-based research projects that covered topics from forest ecology to meteorology. He has conducted numerous wetland studies, protected species surveys, habitat restoration projects, timber resource surveys, and reforestation projects throughout the southeastern U.S. and the Caribbean Islands. He has participated in an assessment of biodiversity and in the Siberian Region of the Commonwealth of Russia, as well as serving on wetland forums for the EPA, Clemson University, the State of South Carolina, and others. He also is a former member of the planning board of Dorchester County, South Carolina.

Tracy Skrabal
Tracy Skrabal holds a masters degree in marine science and a B.S. in geology from the College of William and Mary. Having held positions with the Virginia Institute of Marine Science and the Delaware Department of Natural Resources and Environmental Control, she has accumulated more than 17 years experience in planning and implementing coastal conservation projects. Tracy currently oversees restoration and stabilization projects for the North Carolina Coastal Federation, and she leads their field office in Wilmington, N.C.

Kevin Smith
Kevin Smith is a graduate of the University of Maryland and has worked for 22 years with the Maryland Department of Natural Resources (DNR) in the enhancement and restoration of tidal and nontidal wetlands and streams. Currently, he is chief of Restoration Services at DNR, where most work is focused on restoring hydrologic function to shorelines, streams and wetlands within the coastal plain of Maryland. This work includes the restoration of fish passage and enhancement of spawning and juvenile fish habitat within the tidewater region.

John Wallace
John D. Wallace is currently the refuge manager of the Laguna Atascosa National Wildlife Refuge and the deputy project leader for the South Texas Refuge Complex. After earning a B.S. in wildlife science from Texas A&M University-College Station in 1971, he worked as a veterinarian assistant in Bastrop, Texas (his hometown) and then taught math and science for the Bastrop Independent School District before beginning his career in wildlife conservation in 1973 with the Texas Parks and Wildlife Department. After 18 years with the Wildlife Division of the Texas Parks and Wildlife Department, where he worked in Northeast Texas as a wildlife biologist and wildlife district supervisor, Wallace went to work for the USFWS in 1992 as a supervisory refuge operations specialist at the Lower Rio Grande Valley National Wildlife Refuge. In 1997, he moved to North Carolina, serving first as refuge manager at Mackay Island and Currituck National Wildlife Refuges and then as the deputy project leader for the Alligator River National Wildlife Refuge Complex. In 2002, he returned to Texas to work in his present position. He lives with his wife and two daughters in Harlingen, Texas.

Pace Wilber
Pace Wilber, Ph.D., has worked for NOAA for over 12 years and currently leads the Atlantic Habitat Conservation Branch of the NOAA Fisheries Southeast Regional Office. At NOAA's Fisheries Service, he works with coastal resource managers to incorporate knowledge of ecosystem process into resource management decisions that affect coastal and riverine habitats used by fishery resources. Before working for NOAA, Pace worked for the USACE Waterways Experiment Station in Vicksburg, Mississippi, where he combined engineering models and traditional biological sampling to examine the effects of dredging, beach nourishment, and habitat restoration on coastal ecosystems. He has also worked for the Florida Department of Environmental Regulation, where he served as the department's federal liaison, and for the Smithsonian Institution, where he managed an aquaculture laboratory in the Turks and Caicos Islands.

Appendix C: Participant List

Nicole Adimey
US Fish and Wildlife Service
nicole_adimey@fws.gov

Devendra Amatya
U.S. Department of Agriculture Forest Service SRS
damatya@fs.fed.us

Michael Andersen
Tidewater Environmental Services, Inc.
mike@tidewaterenvironmental.com

Feleke Arega
South Carolina Department of Natural Resources (DNR)
aregaf@dnr.sc.gov

Straud Armstrong
South Carolina DNR
armstrongs@dnr.sc.gov

Craig Aubrey
U.S. Fish and Wildlife Service
craig_aubrey@fws.gov

Danielle Bamford
NOAA Coastal Services Center
danielle.bamford@noaa.gov

Lee Becker
EA Engineering, Science and Technology, Inc.
lbecker@eaest.com

Kristopher Benson
NOAA Restoration Center
kristopher.benson@noaa.gov

Joe Berg
Biohabitats, Inc.
jberg@biohabitats.com

Anne Blair
NOAA National Centers for Coastal Ocean Science and Hollings Marine Lab
anne.blair@noaa.gov

Jeff Boltz
EA Engineering, Science and Technology, Inc.
jboltz@eaest.com

Amy Borde
Battelle Marine Sciences Lab
amy.borde@pnl.gov

Chris Boyd
Mississippi-Alabama Sea Grant Consortium
cboyd@ext.msstate.edu

Ron Brockmeyer
St. Johns River Water Management District
rbrockmeyer@sjrwmd.com

Stephen Broome
N.C. State University
stephen_broome@ncsu.edu

David Burdick
University of New Hampshire
david.burdick@unh.edu

Greg Cassidy
South Carolina Department of Health and Environmental Control
cassidga@dhec.sc.gov

Theresa Cauthen
Hans Wilson & Associates, Inc.
theresa@hanswilson.com

Scott Coleman
Little St. Simons Island
scottc@littlestsimonsisland.com

Mary Conley
The Nature Conservancy
mconley@tnc.org

Leslie Craig
NOAA Restoration Center
Leslie.Craig@noaa.gov

John deMond
Louisiana Department of Environmental Quality
john.demond@la.gov

Angel Dieppa
Jobos Bay NERR
adieppa@gmail.com

Tom Dillon
NOAA Office of Response and Restoration
tom.dillon@noaa.gov

Sadie Drescher
S.C. DHEC OCRM
dreschsr@dhec.sc.gov

Gene Eidson
Clemson University
geidson@clemson.edu

Kelly Filer
University of Georgia
kfiler@uga.edu

Joel Fleming
Georgia DNR CRD
jfleming@dnr.state.ga.us

Michel Gielazyn
NOAA Office of Response and Restoration
michel.gielazyn@noaa.gov

Paul Haydt
St. Johns River Water Management District
phaydt@sjrwmd.com

Brandt Henningsen
SWIM Program - Southwest Florida Management District
brandt.henningsen@swfwmd.state.fl.us

Eric HoChan
Hans Wilson & Associates, Inc.
eric@hanswilson.com

Dionne Hoskins
NOAA Fisheries Service
dionne.hoskins@noaa.gov

Dorset Hurley
Sapelo Island NERR
dhurley@darientel.net

Anand Jayakaran
Clemson University
ajayaka@clemson.edu

Cecil Jennings
US Geological Survey
jennings@uga.edu

Joe Kelley
The Citadel
Joe.Kelley@citadel.edu

Jon Lattimore
Savannah State University
lattimoj@savstate.edu

Leo Lentsch
ENTRIX
llentsch@entrix.com

Robin Lewis
Lewis Environmental
lesrrl3@aol.com

Daphne Macfarlan
NOAA Restoration Center
daphne.macfarlan@noaa.gov

Hassan Mashriqui
LA Sea Grant at LSU
cemash@lsu.edu

Krista McCraken
NOAA Coastal Services Center
krista.mccraken@noaa.gov

Robert McGuinn
NOAA Coastal Services Center
Robert.McGuinn@noaa.gov

Marti McGuire
NOAA Restoration Center
marti.mcguire@noaa.gov

Mark Messersmith
SC DHEC OCRM
messermj@dhec.sc.gov

Scott Neubauer
Baruch Marine Field Laboratory
University of South Carolina
scott@belle.baruch.sc.edu

Doreen Parés
Puerto Rico DNER
dpares@drna.gobierno.pr

Walter Priest
NOAA Restoration Center
walter.priest@noaa.gov

Thomas Ries
PEER, Inc.
tries@peerinc.org

Scott Robinson
Southeast Aquatic Resources Partnership
scott_robinson@dnr.state.ga.us

Lawrence Rozas
NOAA Fisheries
lawrence.rozas@noaa.gov

Bart Sabine
Sabine & Waters, Inc.
bart@sabinc.net

Howard Schnabolk
NOAA Restoration Center
Howard.Schnabolk@noaa.gov

Tracy Skrabal
N.C. Coastal Federation
Tracys@nccoast.org

Brian Smith
NOAA Coastal Services Center
Brian.M.Smith@noaa.gov

Kent Smith
Florida Fish and Wildlife Conservation Commission
kent.smith@myfwc.com

Kevin Smith
Maryland DNR
kmsmith@dnr.state.md.us

Jeffrey Spratt
The Nature Conservancy
jspratt@tnc.org

Anna Toline
ENTRIX
atoline@entrix.com

Jim Turek
NOAA Restoration Center
James.G.Turek@noaa.gov

Vivian Vera
Puerto Rico DNER
vvera@drna.gobierno.pr

John Wallace
USFWS
John_Wallace@fws.gov

Bethney Ward
NOAA Coastal Services Center
bethney.ward@noaa.gov

Priscilla Wendt
South Carolina DNR
wendtp@dnr.sc.gov

Marguerite Whilden
The Terrapin Institute
mwhilden@comcast.net

David Whitaker
South Carolina DNR
WhitakerD@dnr.sc.gov

Van Whitehead
SC DHEC
whitehme@dhec.sc.gov

Pace Wilber
NOAA Fisheries Service
Pace.Wilber@noaa.gov

Sean Willard
IM Systems Group
willards@imsg.com

Patrick Williams
National Marine Fisheries Service
patrick.williams@noaa.gov

Charles Williams
SC DHEC
williacj@dhec.sc.gov

Appendix D: Workshop Evaluation Form

My affiliation can best be described as:

___ Government ___ Academia ___ Private Sector ___ Non Governmental Organization

My experience level with hydrologic restoration projects can best be described as:

___ Little/No Experience ___ Some Experience ___Expert

I am planning to implement a hydrologic restoration project within:

___ 1-2 years ___ 3-5 years___ ___None at this time

Section I. Workshop Goals
How well did the workshop support its goals? Circle the best response.

The workshop:	Not at all (1)	Somewhat (2)	Agree (3)	Very much (4)	Does not apply
• Increased my knowledge of strategies related to tidal hydrology restoration	**1**	**2**	**3**	**4**	**NA**
• Provided a beneficial exchange of information	**1**	**2**	**3**	**4**	**NA**
• Allowed me to address challenges I face in implementing hydrologic restoration projects	**1**	**2**	**3**	**4**	**NA**
• Increased or enhanced my ability to implement hydrologic restoration projects	**1**	**2**	**3**	**4**	**NA**

I will use the knowledge and strategies learned to plan and implement tidal hydrologic restoration projects.
Circle the best response.

Not at All	Somewhat Likely	Likely	Very Likely	Does not Apply
(1)	**(2)**	**(3)**	**(4)**	**(NA)**

Section II. Workshop Format and Content
What did you think about the structure of the workshop? Circle the best response.

	Not at all (1)	Somewhat Disagree (2)	Somewhat Agree (3)	Mostly Agree (4)	Fully Agree (5)
• The content of the workshop was relevant to my work or interests.	**1**	**2**	**3**	**4**	**5**
• The presentations were beneficial.	**1**	**2**	**3**	**4**	**5**
• The breakout sessions were beneficial.	**1**	**2**	**3**	**4**	**5**
• There was ample opportunity to network with others.	**1**	**2**	**3**	**4**	**5**
• The length of the workshop was appropriate to cover the material presented.	**1**	**2**	**3**	**4**	**5**
• The time allotted for presentations and breakout sessions was well balanced.	**1**	**2**	**3**	**4**	**5**
• The appropriate audience was targeted to attend this workshop.	**1**	**2**	**3**	**4**	**5**
• The workshop size (# of attendees) was	Too small **1**	**2**	Just Right **3**	**4**	Too Large **5**
• The scope of the workshop was	Too narrow **1**	**2**	Just Right **3**	**4**	Too Broad **5**
• Overall, I am satisfied with the workshop.	Not at all **1**	Somewhat Disagree **2**	Somewhat Agree **3**	Mostly Agree **4**	Fully Agree **5**

Section III. Workshop Venue
Were you satisfied with the accommodations? Circle the best response.

• The meeting rooms were	Uncomfortable **1**	**2**	Average **3**	**4**	Comfortable **5**
• Meals and refreshments were	Poor Quality **1**	**2**	**3**	**4**	Excellent **5**
• Registration process was	Difficult **1**	**2**	**3**	**4**	Easy **5**
• Hotel Accommodations	Uncomfortable **1**	**2**	Average **3**	**4**	Comfortable **5**

Section IV. Comments

What was the most valuable part of the workshop for you? Why?
What was the least valuable part of the workshop for you? Why?
Any additional comments would be appreciated.

Appendix E: Workshop Evaluation Summary

Participant Information

- Approximately 64% of the respondents were affiliated with government, about 18% from academia, 11% from the private sector, and roughly 7% affiliated with an NGO;
- 42% considered themselves to have some experience in hydrologic restoration projects, 40% with little or no experience, and 18% considered themselves experts;
- The majority of respondents plan to implement a project within 2 years (64%)

Workshop Objectives

- A strong majority felt the workshop increased their knowledge of restoration strategies (~ 90%)
- A strong majority felt the workshop provided a beneficial exchange of information (~95%)
- A majority felt the workshop allowed them to address challenges faced in project implementation (~70%)
- A strong majority felt the workshop enhanced their ability to implement projects (~80%)
- Approximately 79% of respondents said it was likely or very likely that they would use the knowledge and strategies learned at the workshop to plan and implement tidal hydrologic restoration projects.

Appendix F: Relevant Literature

Anisfeld, S.C., M. Tobin, and G. Benoit. 1999. “Sedimentation Rates in Flow-Restricted and Restored Salt Marshes in Long Island Sound.” *Estuaries*. 22. Pages 231 to 244.

Bolduc, F., and A.D. Afton. 2004. “Hydrologic Aspects of Marsh Ponds during Winter on the Gulf Coast Chenier Plain, USA: Effect of Structural Marsh Management.” *Marine Ecology Progress Series*. 266. 35 to 42.

Boumans, R.M., and J.W. Day. 1994. “Effects of Two Louisiana Marsh Management Plans on Water and Materials Flux and Short-Term Sedimentation.” *Wetlands*. 14. Pages 247 to 261.

Boyer, M.E. 1997. “The Effect of Long-Term Marsh Management on Land-Loss Rates in Coastal Louisiana.” *Environmental Management*. 21. Pages 97-104.

Brinson, M. M., R. R. Christian, and L. K. Blum. 1995. “Multiple States in the Sea Level Induced Transition from Terrestrial Forest to Estuary.” *Estuaries*. 18. Pages 648 to 659.

Bryant, J.C., and R.H. Chabreck. 1998. “Effects of Impoundment on Vertical Accretion of Coastal Marsh.” *Estuaries*. 21. Pages 416 to 422.

Cabanes, C., A. Cazenave, and C. Le Provost. 2001. “Sea Level Rise During the Past 40 Years Determined from Satellite and In Situ Observations.” *Science*. 294. Pages 840 to 842.

Cahoon, D.R. 1994. “Recent Accretion in Two Managed Marsh Impoundments in Coastal Louisiana.” *Ecological Applications*. 41. Pages 166 to 176.

Cowan, J.H., Jr., R.E. Turner, and D.R. Cahoon. 1988. “Marsh Management Plans in Practice: Do They Work in Coastal Louisiana, USA?” *Environmental Management*. 12. Pages 37 to 53.

Dahdouh-Guebas, F., and N. Koedam. 2006. “Coastal Vegetation and the Asian Tsunami.” *Science*. 311. Page 37.

Danielsen, F., M.K. Sorenson, M.F. Olwig, et al. 2005. “The Asian Tsunami: A Protective Role for Coastal Vegetation. *Science*. 310. Page 643.

Day, J.W., D.F. Boesch, E.J. Clairain, et al. 2007. “Restoration of the Mississippi Delta: Lessons from Hurricanes Katrina and Rita.” *Science*. 315. Pages 1679 to 1684.

Dean, R.G., and C.J. Bender. 2006. “Static Vase Setup with Emphasis on Damping Effects by Vegetation and Bottom Friction. *Coastal Engineering*. 53. Pages 149 to 156.

De Jong, D.J., Z. De Jong, and J.P.M. Mulder. 1994. “Changes in Area, Geomorphology and Sediment Nature of Salt Marshes in the Oosterschelde Estuary (Southwest Netherlands) Due to Tidal Changes.” *Hydrobiologia*. 282 and 283. Pages 303 to 316.

De Leeuw, J., L.P. Apon, P.M.J. Herman, W. de Munck, and W.G. Beeftink. 1994. “The Response of Salt Marsh Vegetation to Tidal Reduction Caused by the Oosterschelde Storm-Surge Barrier.” *Hydrobiologia*. 282 and 283. Pages 335 to 353.

Georgiou, I.Y., D.M. FitzGerald, and G.W. Stone. 2005. “The Impact of Physical Processes along the Louisiana Coast.” *Journal of Coastal Research*. 44. Pages 72 to 89.

Gilmore, R.G., D.W. Cooke, and C.J. Donohoe. 1982. “A Comparison of the Fish Populations and Habitat in Open and Closed Salt Marsh Impoundments in East-Central Florida.” *Northeast Gulf Science*. 5. Pages 25 to 37.

Harrington, R.W., and E.S. Harrington. 1982. “Effects on Fishes and Their Forage Organisms of Impounding a Florida Salt Marsh to Prevent Breeding by Salt Marsh Mosquitoes.” *Bull Mar. Sci.* 33. Pages 523 to 531.

Hasbrouck, B., and C. Messenkopf. 1997. “Successful Creation of an Oligohaline Environment as Wetland Mitigation.” Pages 193 to 203 in *Tampa Bay Area Scientific Information Symposium: BASIS 3, Applying Our Knowledge*. S. Treat, Editor. Tampa Bay Regional Planning Council, St. Petersburg, Florida.

Herke, W.H. 1995. “Natural Fisheries, Marsh Management, and Mariculture: Complexity and Conflict in Louisiana.” *Estuaries*. 18. Pages 10 to 17.

Herke, W.H., E.E. Knudsen, P.A. Knudsen, and B.D. Rogers. 1992. “Effects of Semi-Impoundment of Louisiana Marsh on Fish and Crustacean Nursery Use and Export.” *North American Journal of Fisheries Management*. 12. Pages 151 to 160.

Herke, W.H., B.D. Rogers, V.L. Wright, and H.W. Bradshaw. 1996. “Postlarval Penaeus Aztecus and P. Setiferus Transport into, and Distribution within, Adjacent Weired and Unweired Ponds.” *Wetlands*. 16. Pages 197 to 207.

Hoese, H.D., and M. Konikoff. 1995. “Effects of Marsh Management on Fisheries Organisms: The Compensatory Adjustment Hypothesis.” *Estuaries*. 18. Pages 180 to 197.

Ivins, E.R., R.K. Dokka, and R.G. Blom. 2007. “Post-Glacial Sediment Load and Subsidence in Coastal Louisiana.” *Geophysical Research Letters*. 34. L16303.

Koch, E.W., and G. Giselher. 1999. “Water Flow in Tide- and Wave-Dominated Beds of the Seagrass Thalassia Testudinum.” *Marine Ecology Progress Series*. 184. Pages 63 to 72.

Knudsen, E.E., R.F. Paille, B.D. Rogers, W.H. Herke, and J.P. Gearghan. 1989. “Effects of a Fixed-Crest Weir on Brown Shrimp Penaeus Aztecus Growth, Mortality, and Emigration in a Louisiana Coastal Marsh.” *N. Am. J. Fish Man*. 9. Pages 411 to 419.

Kuhn, N.L., I.A .Mendelssohn, and D.J. Reed.1999. “Altered Hydrology Effects on Louisiana Salt Marsh Function.” *Wetlands*. 19. Pages 617 to 626.

Massel, S.R., K. Furukawa, and R.M. Brinkman. 1999. “Surface Wave Propagation in Mangrove Forests.” *Fluid Dynamics Research*. 24. Pages 219 to 249.

Mazda, Y., M. Magi, I. Yoshichika, et al. 2006. “Wave Reduction in a Mangrove Forest Dominated by Sonneratia sp.” *Wetlands Ecology and Management*. 14. Pages 365 to 378.

Matheson, R., R. McMichael, D. Leffler, and T. MacDonald. 2005. “Populations of Juvenile and Small-Adult Fishes in Tampa Bay.” Pages 3 to 18 in Tampa Bay Area Scientific Information Symposium: BASIS 4, Linking Science to Management. S. Treat, Editor. Tampa Bay Regional Planning Council, St. Petersburg, Florida.

McGovern, J.C., and C.A. Wenner. 1990. “Seasonal Recruitment of Larval and Juvenile Fishes into Impounded and Non-Impounded Marshes.” *Wetlands*. 10. 203 to 221.

Michener, W. K., E. R. Blood, K. L. Bildstein, M. M. Brinson, and L. R. Gardner. 1997. “Climate Change, Hurricanes and Tropical Storms, and Rising Sea Level in Coastal Wetlands.” *Ecological Applications*. 7. Pages 770 to 801.

Minello, T. J., G. A. Matthews, P. Caldwell, and L. P. Rozas. 2008. Population and production estimates for decapod crustaceans in wetlands of Galveston Bay, Texas. *Transactions of the American Fisheries Society* 137:129-146.

Minello, T. J. and L. P. Rozas. 2002. Nekton in Gulf Coast wetlands: fine-scale distributions, landscape patterns, and restoration implications. *Ecological Applications* 12:441-455.

Montague, C.L., A.V. Zale, and H.F. Percival. 1987. “Ecological Effects of Coastal Marsh Impoundments: A Review.” *Environmental Management*. 11. Pages 743 to 756.

Morris, J. T., P. V. Sundareshwar, C. T. Nietch, B. Kjerfve, and D. R. Cahoon. 2002. “Responses of Coastal Wetlands to Rising Sea Level. *Ecology*. 83. Pages 2869 to 2877.

Neubauer, S. C. 2008. “Contributions of Mineral and Organic Components to Tidal Freshwater Marsh Accretion.” *Estuarine Coastal and Shelf Science* in press.

Neubauer, S. C., and C. B. Craft. “Global Change and Tidal Freshwater Wetlands: Scenarios and Impacts.” A. Barendregt, D. F. Whigham, and A. H. Baldwin, editors. *Tidal Freshwater Wetlands*. Backhuys Publishers, in press, Leiden, The Netherlands.

Nyman, J.A., and R.H. Chabreck. 1996. “Some Effects of 30 Years of Weir-Management on Coastal Marsh Aquatic Vegetation and Implications to Waterfowl Management.” *Gulf Mex. Sci.* 14. Pages 16 to 25.

Nyman, J.A., R.H. Chabreck, and R.G. Linscombe. 1990. “Effects of Weir Management on Marsh Loss, Marsh Island, Louisiana, USA.” *Environmental* Management. 14. Pages 809 to 814.

Penland, S., P.F. Connor, Jr., S. Fearnley, and S.J. Williams. 2005. “Changes in Louisiana’s Shoreline: 1855-2002.” *Journal of Coastal Research*. 44. Pages 7 to 39.

Portnoy, J.W. 1999. “Salt Marsh Diking and Restoration: Biogeochemical Implications of Altered Wetland Hydrology.” *Environmental Management*. 24. Pages 111 to 120.

Portnoy, J.W., and A.E. Giblin. 1997. “Biogeochemical Effects of Seawater Restoration to Diked Salt Marshes.” *Ecol. Appl*. 7. Pages 1054 to 1063.

Raposa, K.B., and C.T. Roman. 2001. “Seasonal Habitat-Use Patterns of Nekton in a Tide-Restricted and Unrestricted New England Salt Marsh.” *Wetlands*. 21. Pages 451 to 461.

Raposa, K.B., and C.T. Roman. 2003. “Using Gradients in Tidal Restriction to Evaluate Nekton Community Responses to Salt Marsh Restoration.” *Estuaries*. 26. Pages 98 to 105.

Reed, D.J. 1992. “Effect of Weirs on Sediment Deposition in Louisiana Coastal Marshes.” *Environmental Management*. 16. Pages 55 to 65.

Reed, D.J., N. De Luca, A.L. Foote. 1997. “Effect of Hydrologic Management on Marsh Surface Sediment Deposition in Coastal Louisiana.” *Estuaries.* 20. Pages 301 to 311.

Rey J.R., J.Shaffer, D. Tremain, R.A. Crossman, and T. Kain. 1990. “Effects of Re-Establishing Tidal Connections in Two Impounded Subtropical Marshes on Fishes and Physical Conditions.” *Wetlands*. 10. Pages 27 to 45.

Rogers, B.D., W.H. Herke, and E.E. Knudsen. 1992a. “Effects of Three Different Water-Control Structures on the Movements and Standing Stocks of Coastal Fishes and Macrocrustaceans.” *Wetlands*. 12. Pages 106 to 120.

Rogers, D.R., B.D. Rogers, and W.H. Herke. 1992b. “Effects of a Marsh Management Plan on Fishery Communities in Coastal Louisiana.” *Wetlands*. 12. Pages 53 to 92.

Rogers, D.R., B.D. Rogers, and W.H. Herke. 1994. “Structural Marsh Management Effects on Coastal Fishes and Crustaceans.” *Environmental Management*. 18. Pages 351 to 369.

Rozas, L.P., P. Caldwell, and T. J. Minello. 2005. The fishery value of salt marsh restoration projects. *Journal of Coastal Research* Special Issue 40:37-50.

Rozas, L.P., and Minello, T.J. 1999. “Effects of Structural Marsh Management on Fishery Species and Other Nekton Before and During a Spring Drawdown.” *Wetlands*. *Ecol. Manage*. 7. Pages 121 to 139.

Ruber, E., A. Gilbert, P.A. Montagna, G. Gillis, and E. Cummings. 1994. “Effects of Impounding Coastal Salt Marsh for Mosquito Control on Microcrustacean Populations. *Hydrobiologia*. 293. Pages 497 to 503.

Schekkerman, H., P.L. Meininger, and P.M. Meire. 1994. “Changes in the Waterbird Populations of the Oosterschelde (Southwest Netherlands) as a result of Large-Scale Coastal Engineering Works.” *Hydrobiologia.* 282/283. Pages 509 to 524.

Swenson, E.M., and R.E. Turner. 1987. “Spoil Banks: Effects on a Coastal Marsh Water-Level Regime.” *Est Coast Shelf Sci*. 24. Pages 599 to 609.

Trepagnier, C.M., M.A. Kogas, R.E. Turner. 1995. “Evaluation of Wetland Gain and Loss of Abandoned, Agricultural Impoundments in South Louisiana, 1978-1988.” *Restoration Ecology*. 3. Pages 299 to 303.